5.4 Novel Aspects of Point-To-Point Systems

Economical point-to-point relay links become increasingly important as the range of end links diminishes to tens of meters. Existing licensed radio infrastructure almost universally uses the telecom synchronous digital hierarchy with full time channel use. Avoidance of delay and cost in changing to/from this format must be avoided in the repeaters and relay links.

The key to the economic and functional success of relay links is using the same formats and protocols as in the end links making a minimal function repeater possible. The relay link system is envisioned as using substantially the same radios as in the access-points, but built into the directive antenna.

> It is recommended that T-1 or equivalent PCM interfaces *NOT be supported* directly because that type of operation would cause transmitters to be continuously ON whether used or not. On the other hand, providing the equivalent 24 B channels would be a permitted service performed by the radio system provided only that air time is not used unless useful information is being transferred. A manageable exception to this rule might be allowed outside of urban and large city suburban areas, however it will be found that once the burst mode multiplex type of equipment is designed and available, the economic advantage of T-1 type equipments will become negative.

The plan and rules given above consider the use of the point-to-point radio is the same bands as the end links. Many of the new possibilities exist because the point-to-point transmitters are only ON when carrying information. *It is possible to divide time between end and relay links using a common channel.* Further separation is possible in space between interior and outdoor systems and by modulation method.

A point-to-point support for short reach fixed access-points should be an integrated portion of the plan for these frequencies. However useful point-to-point may be for random links for telecom or data in an urban area, it will be more significant as a key component of a general wireless access plan.

The implementation of systems where the available frequency space is used in different ways on different premises as an owner option is considered very important. A following major Section takes up this possibility in further detail.

5.5 Use Of Narrower Band Frequency Division Channels

There are cases where narrow band channels are advantageous for the combination of lower peak rate and aggregate system capacity occur together. The argument is not whether they are useful, but whether 5 GHz microwave should be used for this purpose. It is probable that there is a good case for some narrow band point-to-point microwave, but the case is much weaker for end links.

This proposal suggests two bands each consisting of *seven 2 MHz bandwidth* channels at opposite ends of the spectrum under consideration. With the required burst mode technique, a 24 trunk duplex ADPCM telephone channels could be provided in one bandwidth. It would also be possible to obtain 1.5 to 3.0 Mbps of data transfer rate in one of these channels.

5.5.1 Minimum Useful Channel Bandwidth

Because of limits on economic accuracy of quartz crystals for frequency control, there is a practical limit on minimum bandwidth. The input assumptions are that frequency should be within ±1% of the center frequency of the channel bandwidth (±20 KHz), and that crystals accurate to 2.5 ppm (±13 KHz) over a temperature range is an economic limit. The use of 2 MHz minimum channels is consistent with much more economical 5 ppm crystals which would yield ±26 KHz accuracy.

In this band (5.25 GHz), the extra bandwidth available for lower required data rates should be used for processing gain. With correctly chosen channel coding and demodulation, the bandwidth used in the range calculation is then the bandwidth required by the data transfer rate rather than the bandwidth of the transmitted spectrum or of the receiver IF strip.

5.5.2 Example of One Duplex Telephone Channel

For example: A duplex 32 KBps channel for telephone connections coded with 31 bit spread symbols would enable a processing gain of 15 dB which exactly reverses the bandwidth noise increase from using a channel with a 1 Mbps transfer rate. Since the channel is capable of 2 Mbps, protocol and synchronization overhead is supported for up to 50% of the channel rate. The benefit that is less obvious is that the radio costs less, and the fading and other time dispersion effects will be much lower with the spread channel. A further benefit will be a major increase in the density of possible frequency reuse. All of these benefits taken together will make the net loss of spectrum utilization from the spreading competitive with any of the narrow band options.

5.5.3 Further Comments

Accordingly, it is recommended that the tradeoffs between range, modulation and throughput not be specified but left to the suppliers and purchasers.

The option of narrower spectrum than 2 MHz is not realistically useful. The benefits of getting more range from less throughput will prevail. It is anticipated that spreading codes of 11, 15 and 31 bits will predominate providing code division separation of 1, 4 and 12 channels with the longer symbols.

The use of CDMA is unrelated to that of Qualcomm in telephone service where multiple user stations appear simultaneously at a common base receiver. It is much more like Omnipoint where overlapping coverages are approximately equal at coverage boundaries and the receiver must pick one or the other of the signals.

The differentiation for the two narrower channelized bands is: 1) point-to-multipoint where the access-point may be non-directional, and 2) point-to-point where both ends of path must be directional.

These bands are not seen to be supporting operation of moving stations, but that should not be prohibited. The common use should be for stations which are fixed when used but portable and quickly moved and setup at new locations.

This band could be used for Apple "community networks" as outdoor point-to-multipoint with greater range in part due to directional antennas at the remote user stations. Apple is believed to reject coded higher rate methods and support frequency division duplex on the basis of cost and complexity—incorrect. Experience has taught that when all costs are considered, the service needed will be furnished at lower cost with wider band less critical radio.

> Wider band receivers need less precision in filtering, less accuracy in frequency control and much less gain between antenna and logic level reducing shielding and internal power supply and filtering requirements. Time division duplexing avoids duplexing filters and isolators, and reduces local oscillator sideband noise requirements. The radio design is simplified since the transmitter does not operate at the same time as the receiver. It is also possible to make some parts of the radio common for both transmit and receive for a further economy. Taken together, these and other factors will result in lower costs.

5.6 Sharing Rules

It is imperative to have rules governing sharing. The case against "polite" deferral systems has been made above. No rules are known which provide an alternative with some kind of originating station test and action. The present best answer is no deferral type rule.

The main sharing rule is that transmitters must not be ON continuously for any longer than they must be. This point will not suffer compromise. The quantitative aspects are suggested in the regulatory recommendations. It should be understood that radio data transfers have to be limited in length for a number reasons. The "segmentation and reassembly" function is necessary for the radio medium (802.11 picked 256 octets as a limit), but it will also be necessary for other reasons. It is already common in communication protocols (e.g., X, Y and Zmodem) to move information in blocks as small as 64 bytes via unreliable mediums. A receive end ACK is the required for each block.

> **The rules should include strong prohibitions on automatic activity generators or protocols deliberately used to discourage effective channel sharing by occupation. This will be tried and used if it works.**

This minimized ON-time methodology is vital to the notion that indoor and outdoor links on the same channel are non-interfering. Even if they are interfering, they have to be ON in the same 50 microsecond interval to contend, and even then the contention may not be visible at the respective receiving points.

It is certain, that the transmitter ON duty cycle in these bands observed at a fixed point will be less than a few percent except for some burst conditions which will be quite temporary. It is far more time efficient to allow all stations to send when they please (in a regulatory sense), and to include an ACK function in the protocol so that failed transfers can be resent. This procedure is already essential when the purpose is to transfer error-free data

Many systems require broadcast of timing and availability information. This should be allowed but limited to a small percentage use of air time (e.g., 1-2%).

5.7 Security Considerations

All transmitters should be manufacture to include a hardware defined 8 octet nationally unique identification data string in every transmission and immediately following synchronization and start delimiter fields. It would be desirable for such number to be issued by the FCC and used as evidence of payment of transmitter license fees. It might be better to include a socket for an enabling identity module.

5.8 New System Capabilities with Electronically Steered Directive Antennas

In wireless LAN systems, it is commonly assumed that both the station and the target access-point use non-directional antennas (a sectoral coverage access-point antenna is considered omni-directional in this Section). If a large open plan office were to use entirely wireless access, it would be highly desirable for stations to use moderately directional antennas (30° beamwidth typical) and for the access-points to have a steerable beamwidth somewhat narrower. Such a steerable antenna must be assigned a new direction for consecutive bursts from different stations.

The inducements to use directive antennas in this way are:

a) Very much reduced long delay multipath time dispersion that causes strong signal data errors.

b) Greatly reduced probability of interference from cochannel frequency reuse in adjoining coverages.

c) Either reduced transmitter power or greater range is available for a given bandwidth communication.

The aggregate effect is far more capacity from a given frequency allocation. It is possible, that this mode could be preferred for wide area communication distribution of 256 Kbps per user station. In this case the user station would have an aimed directive antenna with much higher gain and range.

This type of system should not be required, but tt is very important that it not be excluded by limitations on radiated power (EIRP).

5.9 Power Limitations

Most proposed chassis transmitter power limitations are already converging on a consensus at 100 milliwatts—no exception is taken. Transmitter with 10 milliwatts or less output at the antenna input should by definition be excused from all limitations on radiated power.

Radiated power in point-to-point systems should be minimally limited in point-to-point systems except that if radiated power exceeds a threshhold a form of automatic power control should be required which controls the power to an approximation of the necessary power.

5.9.1 Exception for Non-Urban Areas

Outside of the recognized metropolitan areas, there is no reason to limit antenna gain with 100 milliwatt transmitters. It should be possible to waiver transmitters up to 1 watt. This may be quite valuable in applying the band to types of systems operating in entirely different areas and for different purposes than in urban applications.

The reuse of these frequencies for minimum cost rural systems could be a very important application.

5.9.2 Exception for Small Room Buildings

For a non-obstructed path, the recommended power levels are entirely suitable, but a different model might also be considered. The example might be an office building with a number of small rooms all with doors to a common hallway, or even an apartment or hotel buildings. In such buildings, foil backed insulation is sometimes put in the walls for acoustic attenuation which also shields radios. The coverage plan might be to have an access point with a special narrow beam aimed down the hallway. For each room there might be a passive repeater which is an antenna in the hallway pointed at the access-point and cable connected to a second antenna inside the room. For a case like this, there would be at least 30 dB more path loss, and in some cases 10 dB relief at the access-point transmitter could be quite helpful.

The obvious range extension step is to extend some of the repeaters to up-link active and to run more power from the access-point transmitter. No recommendation is made, but this is a type of application to be considered and not excluded.

5.9.3 Effectiveness of Adaptive Transmitter Power Control

As a concept, it easily understood that there must be some benefit from reducing station power to that needed. In practice it has not worked this way. In analog cellular telephone systems it has been observed that power is reduced only for stations very close to the base station. The main benefit is in reducing the dynamic range of base receivers in disregarding strong signals several channels removed or much less strong signals on adjacent channels.

Station power control does not reduce the interference level in nearby coverages. That benefit comes solely because the stations have far less range than the base-stations/access-point. If in addition the base receiver is not channelized, the dynamic range problem it is meant to address is minimal. Station power control may reduce dynamic range requirements in overlaid and colocated systems using adjacent channels, but it will have almost no value in adjoining system interference levels. By having time division duplex and multiplex, many of the base station dynamic range problems within one system and addressed with adaptive power-control can be made non-existent.

The answer is different for peer-to-peer systems, however there is serious technical difficulty of invoking it in a system where each member of the group is expected to hear all other members—and there are all different propagation paths between them

Without a benefit, station power control should not be required in any of the systems.

On access-points because the power required would be different for each path, it is difficult to implement. In addition, the protocol usually requires that all stations to be able to hear the access-point even though it is only communicating with a particular station. Access-points rarely are in a mode where reduce power is a useful advantage. Nonetheless a few designers might choose to obtain this advantage. Access-point adaptive power control should not be required.

5.10 Channel Bandwidth Maximization, Time Dispersion and Adaptive Equalization

The received signal is the vector sum of many different paths arriving at the receiver with different time delays. Perhaps the three strongest signals are most significant. If the bit rate is 25 Mbps, then paths representing more than 1/25th of a microsecond delay (40 nanosec) appear as intersymbol interference affecting later transmitted bits. It is true that the most direct path being the first to arrive is not necessarily the strongest signal, so preceding as well as following bits may cause intersymbol interference. Lesser path differences cause fading of the current bit.

The faster the bit rate (or chipping rate), the greater the time resolution of the receiver. The 25 Mbps receiver will resolve path differences of 12 meters. *Since the indoor time dispersion is of the order of 40 nanseconds, it is necessary to have a high transfer rate and a large occupied bandwidth to have the possibility of mitigation multipath fading. The 49 MHz wide bands are minimal (6 meters resolution) for a major reduction in the level of multipath fading.*

In HIPERLAN I, each transmission includes in the header a "training symbol" of 480 bits for adaptive equalization. This equalization is reported to make a great difference in the usable range and accuracy of the transmission. This is accepted as experimental fact. The benefit is that apparently much less spectrum is used for a give level of range, accuracy and capacity when compared with systems without equalization, and possibly also with systems using correlation detection methods. At this point some difference in opinion is possible.

Because HIPERLAN I is a peer-to-peer system, the training symbol must appear at the beginning of every transmission, and all receivers on all transmissions must make a new decision on the desired correction. An ATM cell payload is 384 bits. More than 48 bits of protocol overhead is inevitable. Only about 40% of the air time is used for payload transfer.

The first possible reaction would be to send multiple payloads per cell. At 48 octets per payload the quantization delay for a 32 Kbps voice channel is 12 milliseconds. Doubling the payload size doubles the delay to 24 milliseconds and increases the air time used to 60%. To these delays must be added some access and processing delays that may be independent of payload length. In the Bellcore UPCS, a 2 millisecond delay was considered necessary.

This discussion is not meant to indicate that HIPERLAN I or II are bad systems, but rather that a gain in one area may be a loss in another important consideration.

The equalization generally cannot perform on path differences finer than can be resolved by the allowed bandwidth and bit rate, but it can perform on delays that cause intersymbol interference.

A possible solution is to measure the impulse response of the medium by observing a known bit pattern in the transmission physical medium header. The results can be used to weight the evaluation of the incoming signal over an interval of several bits/chips.

In the proposed rules in Section 4.2 e) calls out use of the same antenna for transmitting and receiving. The reciprocity of the paths up and down is important to power control and to some simpler methods of equalization. Since will be the choice of most suppliers independently of the rules, there is value in calling it out so that dependence may be placed on this property.

An alternative mitigation is inherent in any demodulation that uses Barker character or many other forms of spectrum spreading. *The effect of spreading is to dilute the effect of long delayed signals while maintaining complete use of energy on the acquired signal. A spread of as little as 5 chips (more is better) can have great value in increasing signal-to-intersymbol-interference ratio.* If spreading is sufficient to enable code-division separation of overlapping coverages in a reuse pattern, this improvement is greater.

> *The proposed 49 MHz bands should not be compromised by division into more narrower channels. This bandwidth is essential to minimizing fade margin and getting accuracy from indirect propagation paths while at the same time providing as much or more capacity than any narrower band alternative.*

It is probable that different suppliers will take different positions on mitigation of time dispersion effects: 1) do nothing, 2) spread the spectrum and 3) equalize. *At regulatory level, it is hard to see any way to make a choice at this point, except to avoid limiting the alternatives with a bits/Hz rule with difficult to predict consequences.*

6.0 Premise Owner System Options

No unlicensed system can even imagine the possibility of regulatory guarantee of freedom from interference. All of the commercially successful systems will gracefully recover from a moderate fraction of failed transfers. This applies equally to interference between relay links flying over a building and the short reach end links within the building. There will be some interference between contiguous coverages within a building and between closely spaced buildings with different systems. All of this must be tolerated because it can't be cured.

Many of the measures that will reduce or approximately eliminate external interference are within the control of the users and their equipment suppliers, and they should be enabled to used them. One of the most effective tools should be the right of a property owner to control what is used on the premises. There should be no regulatory reduction in flexibility in using allocated bands within a common set of rules. Therefore frequency space can and should be used differently on different premises. The below Table attempts to imagine a few of the ways that users could decide to use the allocation plan give above.

Table IV Alternative Uses for Allocated Channels

Frequency Band 5.150-5.350 GHz	User 1 general premise private system	User 2 HIPERLAN II central control	User 3 Community Network	User 4 Other possibilities
1) 2 MHz chnls Pt-Multipoint	Wireless PBX Access-points		ComNet end links	
2) HIPERLAN I	HPLN I	HPLN I	HPLN I	Guest & adhoc LAN
3) HIPERLAN II WB=2 channels	WATM Access VHR/LR end links	2 x HPLN II end links	2 x HPLN I end links	VHR LAN central control end links
4) WB—HR	WATM Access VHR end links	HPLN II end links	ComNet LR SS end links	LR SS LAN relay links
5) WB—SS	WATM Access VHR relay links	HPLN II relay links	ComNet LR SS relay links	LR SS LAN end links
6) NB Pt-Pt	Inter-building telecom trunks		ComNet LR NB relay links	
7) ISM Band	Guest and ad hoc LAN and 1 watt transmitter point-to-point			

The conclusion that is suggested by this list is that a fixed use-based partitioning of the space between these different types of service would make it rare for more than a few of the allocation channels to be used on any one premise. There should be a set of permitted uses for each channel, and then the premises manager should choose which of these are used on that premise. This is going to happen, regardless of regulations.

On one premise it is unlikely that more than one system from among competing types will be used. The bands should allow use of any of the competing types, or they cannot be fully utilized.

Because of the inherent short reach, geographic micro-management is not only possible but highly desirable.

The tradeoff from a user point of view is that the costs of high available bandwidth are: 1) it is not owned but allowed for use only when needed (like public highways), and 2) some interference from cross-use is inevitable but limited to a low probability.

7.0 Public Access Service Providers

It has been imagined that a portable computer usable in a work environment is also served in airports, convention centers, hotels and other public places. Presently, entirely different radios are required in public and private environments. ***There is a real benefit and need for common radio access environments in public and private places.***

> It is recommended that public access serviced providers be allowed to provide access infrastructure in public places where unselective public entry is allowed or on selective public entry private premises like theaters and convention centers upon invitation of the property owner.

Some of the rules which might be necessary are as follows:

A) Eligibility to provide public access services is restricted by the choice of premise owners or operators, and not by the legal description of the entity.

B) Owners may lease the right to operate radio access infrastructure to no more than one only provider for each widely recognized type of system each operating in only one of the three wide bands.

C) Providers may charge for the service provided based on usage with minimum billing but not for local access. All such providers must find a way to form ***a common billing pool*** that aggregates user charges incurred in different places.

D) Providers must choose only technology for the infrastructure which falls within the rules for private use. Also, any technology chosen must already have a commercially significant market penetration for private use. To this end, no public access may be offered before N (3?) years after the date of legal use for private systems.

E) Providers may not deliberately attempt to provide coverage on a private premise, and may be required to alter their system to avoid overcoverage into private premises.

8.0 Concluding Comments and Recommendations

What is given following are specific comments reference to selected paragraph numbers in the NPRM.

8.1 Comments on NPRM Body Paragraphs 35-56

Para 35: The selection of available frequencies is strongly supported.

Para 36: It is agreed that sharing rules are essential. "Etiquette" in this context has acquired a specific meaning which is not appropriate in these circumstances. (See 2.1, 5.1 and 8.0G. above)

Para 37: EIRP should be +6 dB above 100 milliwatts max if allowable considering interference to other services. Higher EIRP should be allowed outside of urban areas—possibly MTAs. (See 4.2, 5.9 above)

Para 38 & 41: Protocols which define when the transmitter may ON and which define the overhead information associated with each transmission are vital parts of a radio system. It is also necessary to define burst size limits and the detection of and behavior after unsuccessful transfers. Such matters are appropriate for industry standards Committees. This doesn't work very well but there is no alternative.

Para 39: The Apple (and others) arguments against centralized control are unfounded and untenable on a technical basis. Possibly, this is an expression of "paranoia" about inroads of third party infrastructure providers. If barriers against existing and potential pubic access service providers are necessary to prevent private systems from being pre-empted, the problem must be faced directly, and not by crippling the technology that is usable. Moreover, there are circumstances in which a public service provider may enhance the value of private systems. The short range of end links allows geographic management in fine detail. (See 6.0 and 7.0)

Para 40 & 41: Channelization is the most administerable way to manage alternate uses of the same spectrum under different conditions. In this proposal, a compromise is to choose the dimensions compatibly with HIPERLAN I as one of several allowed uses. (See T-III, 4.3-4.5 above)

Para 42: The offered plan uses the space at either end of the wideband suggested allocations for 7 channels of narrow band service of 1/23rd bandwidth. These are the narrowest bands economically feasible considering crystal accuracy. (See 5.5.1 above) The widebands are none too wide at double that of a HIPERLAN channel. Many who are opposed to this docket are insensitive to the value and need for channel coding to resist time dispersion errors and for protocol necessary to assure orderly high accuracy transfers. After these overhead functions, it will be artful to get even 16 Mbits of data throughput in a 46 MHz channel. Also, for data there is no rate so high that it won't be needed if not this year then by the time the equipment is on the market.

Para 43-45: Long reach (10-15 km) is indisputably useful, but so are lesser ranges in other circumstances. The kind of long reach suggested by Microsoft for point-to-multipoint in a neighborhood cannot be achieved with power. If reach between unobstructed path omni-directional antennas is 40 meters, it will be 400 meters if one of them has a narrow beam antenna and 4000 meters if both ends have narrow beam antennas. The energies of those wanting to cover larger areas in this frequency band with high transfer rates should focus their energies on small, economical repeaters and relay links and not on more power. The possibility of code isolation of overlapping point-to-point relay link coverages is new territory in a product sense.

Para 46-47: The 100 milliwatt conclusion is reasonable and livable. 400 milliwatts of EIRP from antenna gain is better. There are reasons for having higher power when non-optical paths are needed, however obstacles generally can't be pierced with power. (See 5.9 above)

Para 48: The 1 watt rules allowed in the high band should also include NII/SuperNet. In future years the use of high GHz bands for short reach relay links is certain to increase, however susceptibility rain, snow and absorbtion losses decrease the usefulness of these frequencies.

Para 51: It is important to specify wide channels early. They can always be split, but never reassembled. Differing partitioning between suppliers is going to complicate interference considerations. It is bettered to indicate a preferred, non-required plan rather than no plan at all.

Para 52: The essentials of a time-based sharing plan are given. (See 4.0 above) Allowing modifications, this will be a contribution at some future meeting on sharing rules. Monitoring is not satisfactory—it will lose more channel time than it gains by unnecessary deferral. (See 5.1) It would be a mistake to be overimpressed by HIPERLAN I

Much shorter limits on transmission time should be considered and dimensioned in payload length if possible to normalize transfer rate. (See 4.2b, 4.4c, 4.6e) Approximate conversion of octets to time should include a factor of more than half (60%) for overhead on short packets of 48 octets and 40% for 256 octet packets. The transmission time must consider channel coding used as well as raw transfer rate.

Para 53: A choice of modulation is a tradeoff. The less bandwidth efficient tend to have higher interference resistance which is also a highly desirable property. Competition will limit most cost-lowering inefficiency. This end will be well served by requiring full occupancy of the available spectrum. Modulations less efficient than GMSK aren't the possibility that they were a few years ago. It would be desirable for the air interface for all modulations used to be publicly disclosed. For the present, there would be as much loss as gain from regulatory modulation specifications.

Para 54: Use for relay links will be very much restricted if roof top antennas are impaired by power reduction. In mobile systems antenna height translated each octave as about 6-9 dB difference. If a rooftop at 30 meters were only penalized by this factor, the result would be livable. If EIRP were translated to power density there would be some relief for those able to use reduced transfer rates. Conditions are so variable that eventually a subjective approximation will be necessary. The one proposed is a good one.

Para 55-56: It is to be hope that users and suppliers would be motivated by maximizing ultimate capacity. One of the most costly of subtle business mistakes is to economize and experience earlier obsolescence. The marketing of licenses by MTA/BTA will surely lead to service providers and fewer links. A better choice would be fee per license based on the megabit-acres made busy by transmitter ON, and better yet to include a time-loading factor.

8.2 Closing Recommendations

A. This frequency space should be mainly used for a major need not within the capabilities of lower frequency allocations: complete coverage of indoor and outdoor premise-areas with high bandwidth, high capacity digital services in which telecom connections and packet LAN are optimized subsets. Economic efficiency requires that this be done with the minimum of protocol changing in the network infrastructure including the relay links supporting the access-points.

B. The regulatory environment should support, at least within one private premise, the possibility of installing only one radio infrastructure for everything. The ATM technology is the only widely accepted transport protocol and format candidate for commonality of infrastructure for packet and connection services—and this is equally true in wide area and local networks. The radio regulations should be harmonized with these goals to the point of preference over traditional overlaid system methods.

C. This spectrum should be equally available to those who operate private premises and to entities that provide public access communication services in public places. Private providers should have primary status within the premises in which they operate. Established service providers should be welcome to provide compatible infrastructure in public places but without any right of exclusion, and on private premises only as a contractor for that purpose, and not by right of franchise.

D. Point-to-point relay links integrated with local distribution end links are vital to the economics of a high bandwidth service. In the early phases and in areas of lower usage, the point-to-point links can operate in the same band as the end links, but they will need their own allocation when the service capacity must be maximized. It is quite possible that a second tier or relay links can be provided in high GHz spectrum where even higher capacities must be provided, and this would moderate the need for point-to-point in the 5 GHz band.

E. To further expand the usefulness of the spectrum, different rules are suggested that might apply outside of urban areas and which enable longer reach and lower cost for rural applications.

F. It is immensely important to provide wide highly-shared bands. The available spectrum should not be finely divided so that the views of each of many gets an allocation—each too small for fast high capacity technology. Those with the same technical need must not be allowed to escape the need for cooperation with other organizations with like-type needs.

G. The proposed Etiquette rule should be permissive for peer-to-peer systems and not apply at all to centrally managed systems. As a default when there is no infrastructure present it could be permitted for all types of systems.

H. There are many more rules required to define the "level playing field" than those given above so that the user cost is not driven up by market fragmentation and incompatibility. Such rules must limit possibilities by limiting assumed models and the permitted multiplexing methods.

I. Regulatory specification of security and identification measures are needed in part because partial implementation may be incapable of detecting misuse and abuse. For example, all transmitters should have machine readable identification to facilitate automatic surveillance for the protection of legitimate users from rogue and counterfeit user groups.

J. "Easy" licensing should be considered for fixed and long reach facilities (over 5 km) and for systems of 5 watts eirp or more. Such licensing would not be exclusive but rather would depend on the cooperation of identified users. The benefits of having all users of the frequency identified within a known geographic boundary would be immensely valuable when usage becomes high.

Potentially, this band can carry orders of magnitude more communication than all the PCS bands taken together. But this benefit will not be realized by extension of unorganized ad hoc technology. It is a potential which, if realized, would make big differences in the way our society communicates and works together.

The position on technology is "live and let live." This is the only alternative which will enable all technologies to have their opportunity to match user needs. The premature formation of standards will be biased to extend the existing technologies of present market leaders rather than to exploit the best possible.

It is the intent of these comments to show many of the technical measures necessary to use the subject radio spectrum space for a level of communication capacity and versatility far exceeding anything provided in the lower frequency spectrum. If regulated along the lines proposed, large economic benefits for commerce, education and government will be created.

Respectfully submitted,

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